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6G Communication Network & Emerging Technologies

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Abstract: The sixth-generation (6G) wireless communication network here is going to integrate with terrestrial, aerial, and maritime communications to make network robust that will be more reliable, fast, and will support a massive number of devices with ultra-low latency requirements. The researchers around the globe are using emerging technologies like artificial intelligence (AI), machine learning (ML), quantum communication, quantum machine learning (QML), block chain, tera-Hertz and millimeter wave's communication, tactile Internet, non-orthogonal multiple access (NOMA), small cells communication, fog, edge computing, etc., with 6G network communication beyond 5G. In this paper, an overview will be provided of 6G network along emerging technologies associated with it.

Keywords: wireless networks, beyond 5G, 6G, 6G mobile communication, terahertz spectrum, terahertz communications, holographic communications, block chain, Cloud, Artificial Intelligence, IoT.

I. INTRODUCTION

As we aware of revolutionary changes in cell phone world .New innovation has been introduced in the field of Wireless Communication. If we talk about 3G, in context of 3G it was good for internet, later was improved. 4G was introduced with good internet and for voice call 4G LTE was introduced later The Fourth Generation Long Term Evolution (4G LTE) technology has increased the bandwidth available for smart phones, in essence, delivering broadband capacity to smart phones[4]. 5G – the latest generation of cellular networks deployed with more features than 4G – it combines different technologies to increase capacity, reduce latency, and saves energy. The most recent 5G technology is enhancing the transmission capacity and reducing latency through the use of different technologies. 5G is expected to provide Internet connections that are at least 40 times faster than 4G LTE [4], but 5G cannot support such a high number of IoT devices [1]. Beyond 5G, some fundamental issues need to be addressed these issues are higher system capacity, higher data rate, lower latency, higher security, and improved quality of service (QoS) compared to the 5G system[2]. The evolution of next-generation communication system i.e. 6G communication network system aims to achieve the issue with 5G i.e. high spectral and energy efficiency, low latency, and massive connectivity because of extensive growth in the number of Internet-of-Tings (IoT) devices. These IoT devices will realize advanced services such as smart traffic, environment monitoring, and control, virtual reality (VR)/virtual navigation, telemedicine, digital sensing, high definition (HD), and full HD video transmission in connected drones and robots. IoT devices are predicted to reach 25 billion by the year 2025 [1], and therefore, it is very Challenging for the existing multiple access techniques to Accommodate such a massive number of devices.

II. LITERATURE SURVEY

As we know rapid development of various emerging technologies as Artificial Intelligence, Block chain, Cloud computing virtual reality (VR), three-dimensional (3D) media, and the Internet of Everything (IoE), had lead to massive amount of traffic volume [2]. In 2010, the globe traffic volume was 7.462 EB/Month and this traffic is predicted to be 5016 EB/Month in 2030 [2].By this analysis, it has been proven that improvement in communication network is required to support these emerging technologies. In some parts of the world 5G have already been deployed, but in some parts it's about to deploy. By 2022, 5G will deploy worldwide. If we consider 5G after 10 years, then it requires some significant improvements over the existing systems, although the 5G communication systems will not be able to fulfill the demands of future emerging intelligent and automation systems [5]. As compared to 4G network communications, 5G provides new features and a better quality of service. As compare to 4G, 5G includes new additional techniques i.e. millimeter waves, advanced spectrum usage and network slicing. The fast growth of data-centric and automated systems may exceed the capabilities of 5G wireless networks. 5G communications covers intelligence, sensing, control, and computing functionalities. However, future IoE applications will necessitate this convergence. Specific devices, such as VR devices, need to go beyond 5G (B5G) because they require a minimum of 10 Gbps data rates [6]. Hence, with 5G reaching its limits in 2030 [2].

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After 5G, 6 Generation (6G) communication network requires (i) massive man-machine interfaces, (ii) ubiquitous computing among local devices and the cloud, (iii) multisensory data fusion to create multi-verse maps and different mixed-reality experiences, and (iv) precision in sensing and actuation to control the physical world[7,9]. Right now only little information is there about the standards of 6G.The estimation of 6G standard will be sorted by 2030 [8]. 6G will be capable of transmitting signal at a human computational capability by 2035, shown by some research centers [9]. International Telecommunication Union Radio communication sector (ITU-R) issued the requirements of International Mobile Telecommunications-2020 (IMT-2020 Standard) in 2015 for the 5G network standards .In 2015, 3GPP issued R13 for 5G standards, 3GPP will also finalize its standardization of 6G in R23 [9]. ITU has established a focus workgroup for exploring the system technologies for B5G/6G systems in July 2018 [7]. The Academy of Finland has founded, 6Genesis, a flagship program focusing on 6G technologies, in 2018 [10]. Similarly, China, the United States of America, South Korea, Japan, Russia have also started the research for B5G/6G communication technologies [8, 9, 10–11]. Evolution of different generation of communication showed in Fig.1. To reach the goal of 6G and to overcome the constraints of 5G for supporting new challenges, B5G wireless systems will need to be developed with new attractive features. The 6G communication networks will fulfill the laggings of 5G system by introducing new synthesis of future services such as ambient sensing intelligence and new human-human and human-machine interaction, a pervasive introduction of AI and the incorporation of new technologies such as terahertz (THz), 3-dimensional (3D) networking, quantum communications, holographic beamforming, backscatter communication, intelligent reflecting surface (IRS), and proactive caching [12].

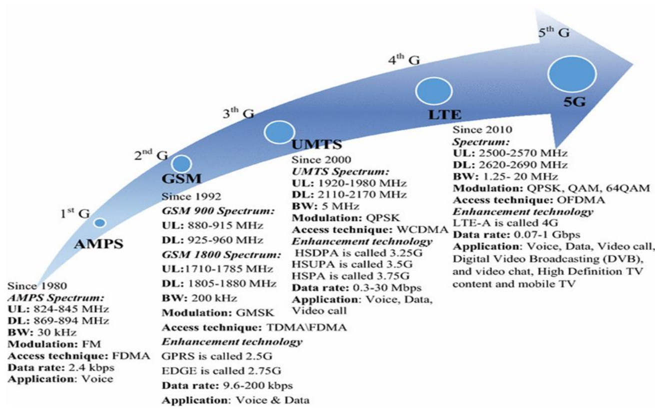

Fig. 1. Evolution of generation of communication

III. 6G COMMUNICATION ARCHITECTURE

Next generation communication consists of large number of connected devices and with the base stations (BSs)/ Access points (APs) leading to mMTC. The huge amount of data produced by massive devices will require very high-performance processing units and robust backhauling links. The central processing units may utilize ML and AI algorithms and the backhauling links may utilize optical fiber and or photonic communications. Remote user, in 6G communication systems, can use several relays or transmitters for a remote user to transmit, and the user’s SINR may be improved by using the technique of diversity as in virtual MIMO systems. Fig 2. Shows some major components in the 6G architecture.

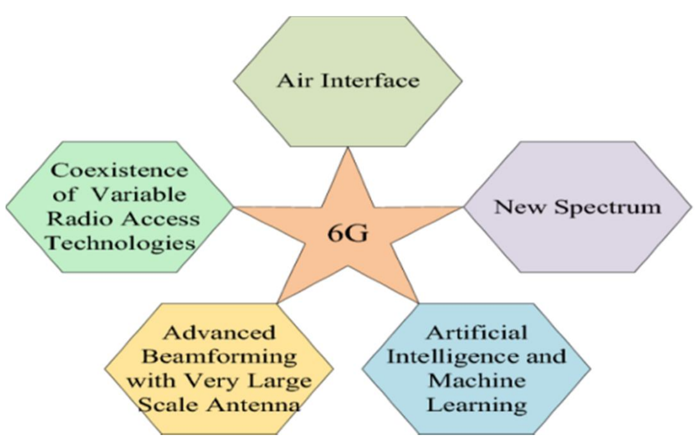

Fig. 2. The shift to 6G Communication

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There are different 5 components for 6G communication network. First talk about air interface, it is the main component which makes a major improvement in the wireless generations. If we talk about code division multiple access CDMA, it was the key player in 3G. Similarly, orthogonal frequency division multiplexing (OFDM) played a major role in the development of 4G. Development of the new air interface will be an essential component of 6G system architecture. AI and ML are another important components of the 6G system architecture.

AI and ML playing an important role in the self-organization, self-healing, self-configuration of 6G wireless systems. Similarly, Spectrum congestion will also be used in the 6G for adopting the new spectrum for communication. Therefore, this new spectrum will also be an active component in the 6G system architecture. Since 6G will accommodate a wide range of communication devices ranging from IoTs to live HD video transmission, 6G will need to be in line with all previous technologies. Therefore, a flexible and multi-radio access technologies (RAT) system architecture will be an essential component in the 6G network.Fig.3 shows the vision of 6G communication networks. With the help of 6G communication network we can cover globally, all spectrums, to implement emerging technologies and can apply network security over it.

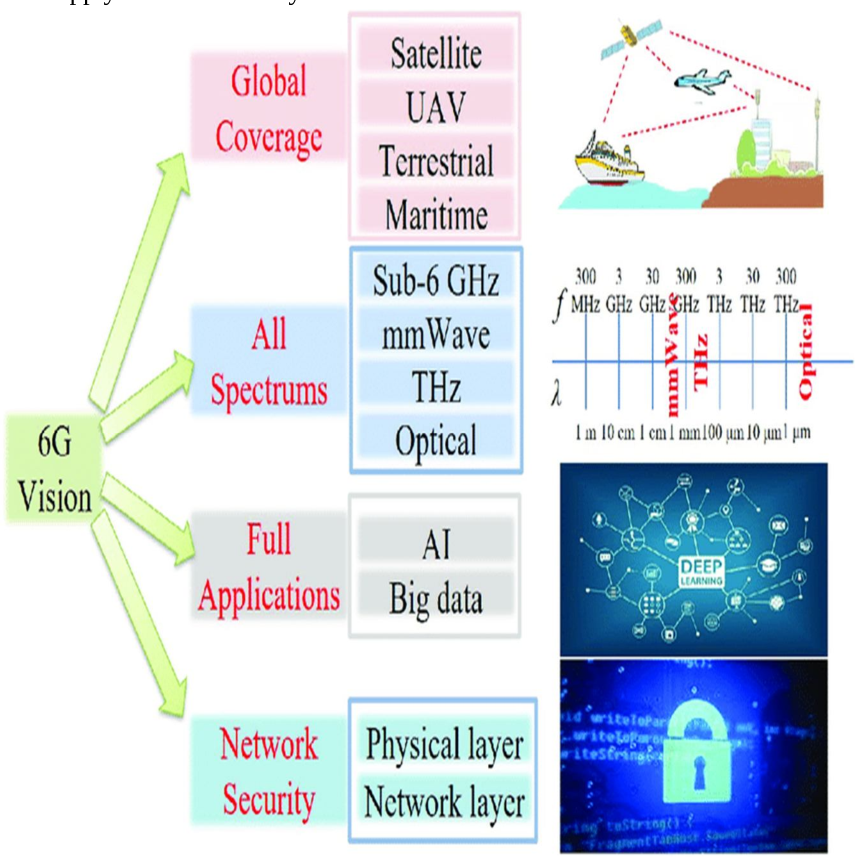

Fig.3. 6G Vision

IV. MOBILE COMMUNICATION TRENDS

The first analog communication system started at 1980s, after every 10 years a new generation of communication introduced. The main of transferring from one generation to another is improvement in QoS metric and adding of new features. The main aim of B5G and 6G is to increase the respective capability

By a factor of 10-100 as compared to previous ones. As compared to last 10 years mobile data traffic has been increased because of the introduction of smart devices and machine to machine communications (M2M). It is expected that the global mobile traffic volume will increase 670 times in 2030 compared to mobile traffic in 2010 [13]. By the end of 2030, the International Telecommunication Union (ITU) predicts overall mobile data traffic will exceed 5 ZB per month. The number of mobile subscriptions will reach 17.1 billion as compared with 5.32 billion in 2010.

It is also being predicted that the use of M2M will also increase exponentially. The volume of traffic for every mobile will also increase. The mobile volume will increase 50 times in 2030 as compared to 2010 that was 5.3 GB per month.

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V. COMPARISION BETWEEN 4G, 5G AND 6G STANDARD COMMUNICATION

Here with the help of table 1 the comparison between 4G, 5G and 6G are shown.

TABLE 1
Comparison of 4G.5Gand 6G

Issue	***4G***	***5G***	***6G***
Per device peak data rate	1Gpbs	10Gbps	1Tbps
End-to-end (E2E) latency	100 ms	10 ms	1 ms
Maximum spectral efficiency	15 bps/Hz	30 bps/Hz	100 bps/Hz
Mobility support	Up to 350 km/hr	Up to 500 km/hr	Up to 1000
Satellite integration	No	No	Fully
AI	No	Partial	Fully
Autonomous vehicle	No	Partial	Fully
XR No Partial Fully	No	Partial	Fully
Haptic Communication	No	Partial	Fully
THz communication	No	Very Limited	Widely
Service level	Video	VR	AR Tactile
Architecture	MIMO	MIMO	Intelligent surface
Issue	4G	5G	6G
Per device peak data rate	1Gpbs	10Gbps	1Tbps
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Haptic Communication	No	Partial	Fully
THz communication	No	Very Limited	Widely
Service level	Video	VR	AR Tactile
Architecture	MIMO	MIMO	Intelligent surface

VI. ENABELING TECHNOLOGIES OF 6G

On the basis of past evolution of mobile networks, initially 6G networks are mostly based on the 5G architecture and inherit the features of 5G. In 6G some new emerging technologies has been implemented and some old features of 5G are being used. Some new technologies has been used in 6G are discussed below.

1) *Artificial Intelligence:* The most crucial and new technology introduced with 6G is artificial intelligence. In 4G communications AI was not involved. In 5G AI is supported partially. But in 6G, for the automatization AI is fully implemented. Real time communication in 6G can be implemented by the advancement in machine learning. By implementing AI in 6G communication standards efficiency will be increased and processing delay will be reduced of the communication. AI will also play a vital role in M2M, machine-to-human, and human-to machine communications. AI technology will help to reach the goals of uMUB, uHSLLC, mMTC, and uHDD services in 6G communications.
2) *Terahertz Communications:* By increasing the bandwidth spectral efficiency can be increased. Bandwidth can be increased by widening the bandwidths and by applying advance massive multiple-input and multiple-output (MIMO) technologies. In 5G mm Wave frequencies were introduced for higher data rates and for enabling new applications. Now, 6G aims to push the boundaries of the frequency band to THz to meet even higher demand. The RF band has been almost exhausted, and now it is insufficient to meet the high demands of 6G. The THz band will play an important role in 6G communication [14-15]. The THz band is intended to be the next frontier of high-data-rate communications. THz waves, also known as submillimeter radiation, usually refer to the frequency band between 0.1 THz and 10 THz with the corresponding wavelengths in the 0.03 mm–3 mm range [16].When the THz band is added to the existing mmWave band, the total band capacity increases a minimum of 11.11 times.
3) *Optical Wireless Technology:* OWC technologies are envisioned for 6G communications in addition to RF-based communications for all possible device-to-access networks; these networks also access network-to-backhaul/front haul network connectivity. OWC technologies have been used since 4G communication systems. However, it is intended to be used more widely to meet the demands of 6G communication systems. OWC technologies, such as light fidelity, visible light communication (VLC), optical camera communication, and FSO communication based on the optical band, are already well-known technologies [2]. These communication technologies will be extensively used in several applications such as V2X communication, indoor mobile robot positioning, VR. Communications based on wireless optical technologies can provide very high data rates, low latencies, and secure communications. LiDAR, which is also based on the optical band, is a promising technology for veryhigh-resolution 3D mapping in 6G communications. OWC confidently will enhance the support of uMUB, uHSLLC, mMTC, and uHDD services in 6G communication systems. Advances in light-emitting-diode (LED) technology and multiplexing techniques are the two critical drivers for the OWC in 6G.
4) *FSO Fronthaul/Backhaul Network:* Due to remote geographical locations and complexities optical fiber connectivity is not always possible as a backhaul network. Moreover, installing optical fiber links for small cell networks may not be a cost-effective solution. The FSO fronthaul/backhaul network is up-and-coming for 5GB communication systems [17]–[20]. The transmitter and receiver characteristics of the FSO system are similar to those of optical fiber networks. Therefore, the data transfer in the FSO system is comparable with the optical fiber system. Hence, along with the optical fiber networks, FSO is an excellent technology for providing fronthaul/backhaul connectivity in 6G. Using FSO, it is possible to have very long-range communications even at a distance of more than 10,000 km. FSO supports high-capacity fronthaul/backhaul connectivity for remote and non-remote areas, such as the sea, outer space, underwater, isolated islands; FSO also supports cellular BS connectivity. FSO fronthaul/backhaul is a common issue both in 5G and 6G networks. However, FSO is more critical in 6G because (i) it requires higher capacity fronthaul/backhaul connectivity and (ii) it will need more number of remote connectivity compared to 5G. FSO communication can support both of the features and became an essential issue for the 6G communication system to boost the uMUB and uHSLLC services. The LD transmitter produces narrow beams of focused light. These beams are used to establish point-to-point high-data-rate communication links between a transmitter and a receiver. FSO systems use laser technology for signal transmission. Long-distance communication is possible because of optical beamforming in FSO systems. The FSO/RF hybrid system will be one of the critical characteristics of FSO based fronthaul/backhaul connectivity in 6G to overcome the limitations of atmospheric effects [2].

5) *Massive MIMO and Intelligent Reflecting Surfaces:* To support uHSLLC, mMTC and uHDD services in 6G systems massive MIMO technology will be crucial. MIMO technique is used to improve the spectral efficiency; it is the most fundamental way. When the MIMO technique is developed, the spectral efficiency is also developed. Therefore, the massive MIMO will be integral to both 5G and 6G systems due to the need for better spectral and energy efficiency, higher data rates, and higher frequencies [12]. Compared to 5G, we expect to shift from traditional massive MIMO toward IRS in 6G wireless systems to offer large surfaces for wireless communications and heterogeneous devices. IRS is a recent hardware technology that has an immense potential toward energy-efficient green communication. It is also known as meta-surface, consists of many reflecting diode units that can reflect any incident electromagnetic signals with an adjustable phase shift. Reconfigurable intelligent surfaces are envisaged as the massive MIMO 2.0 in 6G. These materials can integrate index modulation to increase the spectral efficiency in 6G networks [21]. Gradient descent and fractional programming significantly optimize the intelligent surface phase shifts and transmit power, respectively. With that adjustable reflected phase-shifted signal and the transmitted signal, we can improve the energy efficiency of the system as well. This technology will be considered as a great solution to maximize the data rate and to minimize the transmit power in upcoming 6G networks.
6) *Blockchain:* For managing massive data in future communications system Blockchain is an essential technology. Blockchain is distributed ledger technology. A distributed ledger is a historical collection of data i.e. it's called database which is distributed across numerous nodes or computing devices. Each node replicates and saves an identical copy of the ledger. Peer-to-peer networks manage the blockchains. It can exist without being controlled by a centralized authority or a server. The data on a blockchain is gathered together and structured in blocks. The blocks are connected and secured using cryptography. The blockchain is essentially a perfect complement to the massive IoT with improved security, privacy, interoperability, reliability, and scalability [22]. Blockchain technology will provide several facilities, such as interoperability across devices, traceability of massive data, autonomic interactions of different IoT systems, and reliability for the massive connectivity of 6G communication systems to reach the goal of uHSLLC service. Blockchain builds trust between networked applications, voiding the necessity of trusted intermediaries [23]. Blockchain features, such as decentralized tamper-resistance and secrecy, create the opportunity to make it ideal for numerous applications in 6G communication. It creates a secure and verifiable approach for spectrum management by establishing transparency, verified transactions, and the prevention of unauthorized access. Blockchain combines a distributed network structure, consensus mechanism, and advanced cryptography to represent promising features that is not available in the existing structures. The distributed nature eliminates the single point of failure problem and enhances security. The main challenge of blockchain networking in 5G is the throughputs (10~1000 transactions per second). Another challenge is the demand for local and international standardization and regulation of the massive adoption of blockchain in 5G. Still, 5G considers the issue of smooth interoperability between different blockchain platforms. These several limitations can be mitigated in 6G by using consensus algorithms, applying novel blockchain architecture and sharing techniques, and increasing the block size of the network [2]
7) *3D Networking:* To support communications for users in the vertical extension 6G system will be integrating the ground and airborne networks too. Low orbit satellites and UAVs are provided by 3D BSs [2]. The addition of new dimensions in terms of altitude and related degrees of freedom makes 3D connectivity considerably different from the conventional 2D networks. 3D coverage will be achieved by 6G heterogeneous networks. The decentralized 6G networks with the integration of terrestrial networks, UAV networks, and satellite systems genuinely realize the global coverage and stringent seamless access, even for ocean and mountain areas.
8) *Integration of Wireless Information and Energy Transfer:* In 6G the most innovative technology is WIET in 6G. WIET uses the same fields and waves as wireless communication systems. Sensors and smart phones are charged by using wireless power transfer during communication. WIET is a promising technology for lengthening the lifetime of the battery-charging wireless systems [2]. Hence, devices without batteries will be supported in 6G connections. Moreover, near-field-enabled clothing creates the opportunity for continuous physiological monitoring with battery-free sensors in the medical sector [2].
9) *Integration of Sensing and Communication*: A key driver for autonomous wireless networks is the capability to continuously sense the dynamically changing states of the environment and exchange information among different nodes [2]. In 6G, the sensing will be tightly integrated with communication to support autonomous systems. A massive number of sensing objects, complicated communications resources, multilevel computing resources, and multilevel cache resources are the real challenging factors to achieve this integration.

10) *Integration of Access-Backhaul Networks:* The density of the access networks in 6G will be huge. Each access network relates to backhaul connectivity, such as optical fibers and FSO networks. Access and backhaul networks are tightly integrated to handle most access networks [2].
11) *Big Data Analytics:* Big data analytics is a complex process for analyzing a variety of large data sets or big data. This process uncovers information, such as hidden patterns, unknown correlations, and customer inclinations, to ensure comprehensive data management. Big data is collected from a wide variety of sources, such as videos, social networks, images, and sensors. This technology is widely used for handling a large amount of data in 6G systems. The prospects of leveraging an enormous amount of data, big data analytics, and deep learning tools are anticipated to advance 6G networks through automation and self-optimization. One example of the application of big data analytics is the E2E delay reduction. The combination of machine learning and big data will determine the best path for the user data through predictive analytics to reduce the E2E delay in 6G systems.
12) *Proactive Caching:* Massive deployment of small cell networks for 6G is one of the critical concerns to enhance the network capacity, coverage, and mobility management significantly. This will cause colossal downlink traffic overload at the BSs. Proactive caching has become an essential solution to reduce access delay and traffic offloading, enhancing the user quality-of-experience [2]. However, extensive research on the joint optimization of proactive content caching, interference management, intelligent coding scheme, and scheduling techniques are essential for 6G communication.
13) *Holographic Beamforming:* A signal processing procedure by which an array of antennas can be steered for transmitting radio signals into a specific direction is known as beamforming. It is a subset of smart antennas or advanced antenna systems. The several advantages of beamforming are, high signal-to-noise ratio, interference prevention, and rejection, and high network efficiency. Holographic beamforming (HBF) is a new method for beamforming that is considerably different from the MIMO systems because it uses software-defined antennas. HBF is an advantageous approach in 6G for the efficient and flexible transmission and reception of signals in multi-antenna communication devices. In the field of physical-layer security, wireless power transfer, increased network coverage, and positioning HBF can perform substantial roles [2].

Above different emerging technologies are described that can be used with 6G standard for communication. All technologies have their own significance in 6G. Due to these technologies 6G will became more advance wireless communication standard.

Below table 2 is given about the characterization about different technologies used in different 6G services. As we know 6G provides us different 6G services as uMUB, uHSLLC, mMTC, uHDD. These are the different services provided by 6G. Table 2 defines characterization of different emerging technologies used in different 6G services.

TABLE 2
Different emerging technologies used in different 6G services.

Technology	***uMUB***	***uHSLLC***	***mMTC***	***uHDD***
Artificial Intelligence	Y	Y	Y	Y
Terahertz Communications	Y	Y		
Optical Wireless Technology	Y	Y	Y	Y
FSO Fronthaul/Backhaul Network	Y	Y		
Massive MIMO and Intelligent Reflecting Surfaces		Y	Y	Y
BlockChain		Y		
3D Networking	Y	Y		Y
Integration of Wireless Information and Energy Transfer	Y			Y
Integration of Access-Backhaul Networks	Y			Y
Big Data Analytics		Y	Y	Y
Proactive Caching		Y	Y	Y
Holographic Beamforming		Y		

VII. CONCLUSION

As evolution of new generation communication system brings new and exciting features. If we talk about 5G, which is being deployed world wide by 2021 has new features which makes 5G communication standards more impressive.

But there are some limitations associated with 5G, i.e. 5G will not be able to support the growing demand for wireless communication in 2030 entirely. That's why 6G communication standards are needed and evolved. Research on 6G is still in progress. This paper envisions the prospects and ways to reach the goal of 6G communication. In this paper, I tried to present the possible applications and the technologies to be deployed for 6G communication and also described the possible challenges and research directions to reach the goals for 6G. Besides clarifying the vision and goal of 6G communications, have also stated the various technologies that can be used for 6G communication.

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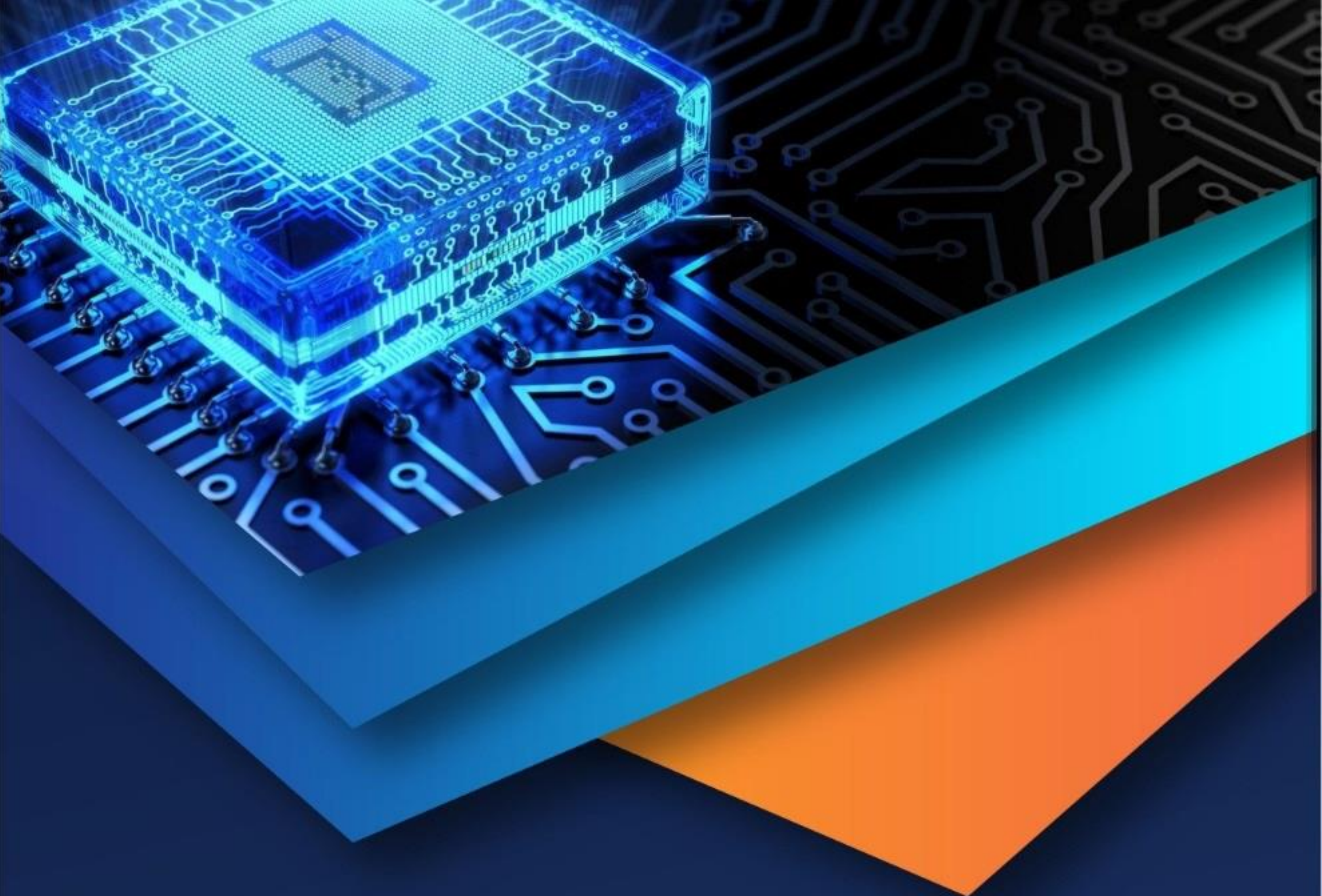

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